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Nature-based solutions as an approach to empower community in programming Curug Kulon green space

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Abstract. Nature-based solution (NBS) has become tools to improve environmental resilience and reduce temperature increases due to global climate change. Although many green spaces are still underutilized and have little ecological, social, or economic value, they are essential to this mission. At the same time, previous research has established NbS as an integrated framework for environmental management, climate adaptation, and its practical implementation, particularly in urban contexts. This study examines the case of Curug Kulon in Tangerang Regency, where green spaces are neglected and only marginally used for urban agriculture. Through land potential analysis and Focus Group Discussions with local stakeholders, the study identified key strategies for programming green spaces based on the socio-cultural characteristics of the community. The results demonstrate (1) the possibility of creating multipurpose land uses, (2) the conversion of local residents into proactive promoters and advocates of environmental conservation, and (3) the incorporation of green space functions as educational areas, productive landscapes, and ecological buffers. Research recommends a participatory framework to improve climate resilience based on community empowerment by developing urban green space program and provides a concept of green space sustainable management.

1 Introduction

Both in developed and developing nations, urban land areas have been increasing significantly since 1990. A comparable trend is apparent in Indonesia. In 2020, 56.7% of citizens lived in cities. By 2035, this number is expected to reach 66.6% [1]. The change in population numbers has led to more land refunction for homes, businesses, and infrastructure, causing degradation of farmland and natural areas. A study of 386 European cities revealed a decrease in the provision of green space per capita as the population density increased. A study of 111 cities in Southeast Asia found the same thing: more people cause less green space, both in total and per person. More people living in an area also means fewer trees and less open space [2]. The persistent expansion of urban areas and the increasing presence of

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industrial spaces within them have become critical factors in the development of social structural change in Indonesian society. This change has also moved the centers of communal activity, which used to be based in rural or traditional settings. As the population grows and industrial zones continue to expand, the citizens daily lives become revolutionized, and also the urban environment becomes increasingly congested [3]. In regions that function as hubs of community activity, the continuous decline of verdant open spaces is particularly apparent due to the loss of rice fields and plantations. However, urban development in many cities is always in line with the degradation of agricultural land, with greenspace alterations occurring mostly along the urban-rural periphery [4].

This condition is detrimental to the environment and poses a significant threat to human existence and all living systems on a broader scale. This type of urban economic development plan makes the loss of biodiversity much worse and doesn't take advantage of the chance to use nature to solve problems with climate change, food security, and lowering the risk of disasters [5]. The Republic of Indonesia's Presidential Regulation from 2022 places a strong emphasis on implementing the Sustainable Development Goals (SDGs), which aim to eliminate poverty, improve well-being, and protect the environment [6, 7]. The integration of Nature-based Solutions (NbS) into urban planning represents a critical approach to addressing these interconnected challenges [8].

The International Union for Conservation of Nature (IUCN) started NbS in 2016. It is a good way to deal with these problems. NbS stress using natural processes to help the environment, society, and economy while also making the climate more resilient [3]. This method is in line with global goals like the SDGs, the UNFCCC, and C40 Cities. People need nature to live and to have a good quality of life. NbS have become an important way to deal with environmental issues all over the world, especially climate change, protecting biodiversity, and making sure that people have fair and acceptable living standards. The Convention on Biological Diversity's Strategic Plan for Biodiversity 2011–2020, the United Nations Framework Convention on Climate Change's Paris Agreement, and the United Nations SDGs are all examples of global initiatives that have these main goals. The IUCN has identified seven global social issues for NbS that are very similar to the urgent needs that these projects have brought to light [8].

Many nations have started to include NbS in their plans for dealing with climate change and to help adress societal challenges [9]. So, it's very important to make sure that these kinds of activities are planned and carried out according to established standards and best practices. The IUCN came up with the first worldwide definition of NbS in 2016 to help with this process [5]. In cities, NbS can look like green roofs, urban forests, wetland parks, and green corridors that help the environment while also solving problems in cities [10]. To put NbS into action, you need to have a good understanding of the local social, economic, and ecological situations. This requires participatory methods that involve local communities in the planning and management process [11]. Community involvement makes sure that NbS interventions are culturally appropriate, socially acceptable, and financially sound [12]. Additionally, participatory planning methodologies can enhance local capacity and foster ownership, which are crucial for the enduring sustainability of NbS initiatives [13].

2 Research theory

2.1 Nature-based Solutions: Theoretical foundation

NbS is a holistic approach that uses natural processes to solve problems in society while also helping the environment, society, and the economy [14]. The theoretical basis of NbS is grounded in ecosystem services theory, which acknowledges that robust ecosystems deliver

critical services such as climate regulation, water purification, carbon sequestration, and biodiversity preservation [15]. The International Union for Conservation of Nature (IUCN) defines NBS as "actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" [13].

NbS must meet eight main requirements: (1) NbS must effectively address societal challenges; (2) the design of NbS must be based on scale; (3) NbS must result in a net gain to biodiversity and ecosystem integrity; (4) NbS must be economically viable; (5) NbS must be based on inclusive, transparent, and empowering governance processes; (6) NbS must equitably balance trade-offs between achieving their primary goal(s) and continuing to provide multiple benefits; (7) NbS must be managed adaptively, based on evidence; and (8) NbS must be sustainable and mainstreamed within an appropriate jurisdictional context [16]. The theoretical framework for the implementation of NBS includes three main areas: social, economic, and environmental [8]:

- Help people deal with climate change: Reduce the impact of climate change on people's lives and assets, such as floods, the security of food and/or water, and the degree of heat stress in urban areas.
- Save more species and keep ecosystems from getting worse: Lower the main sources of threats to certain species and ecosystems, and restore ecosystems with a lot of biodiversity that can help people adapt, protect themselves, and improve their health.
- Make people's lives better by making sure they have enough food or money, helping local people meet their basic needs, or supporting or diversifying nature-based jobs and income streams. People need to understand how much they rely on nature for their basic needs. Such awareness can help with NbS, spatial planning, and online tools that show how ecosystem services are provided [17].

The social-ecological systems framework offers a theoretical perspective for comprehending the intricate relationships between urban green spaces and human communities [18]. This framework acknowledges that green spaces are not solely ecological attributes but are situated within social, economic, and political contexts that affect their planning, management, and utilization [19]. The framework stresses how important it is to understand how social and ecological parts interact with each other and how institutions can help these interactions happen [20].

2.2 Urban green space planning theory

Urban green space planning theory integrates landscape ecology principles with urban planning practice to optimize the ecological, social, and economic benefits of green infrastructure [21]. The theory is grounded in the concept of green infrastructure as a strategically planned network of natural and semi-natural features designed to deliver ecosystem services [22]. Key theoretical concepts include connectivity - ensuring ecological corridors between green spaces, multifunctionality - designing spaces to serve multiple purposes, and accessibility - providing equitable access to green space benefits [23].

The social-ecological systems framework provides a theoretical lens for understanding the complex interactions between urban green spaces and human communities [24]. This framework recognizes that green spaces are not merely ecological features but are embedded within social, economic, and political contexts that influence their planning, management, and use [25]. The framework emphasizes the importance of understanding feedback loops between social and ecological components and the role of institutions in mediating these relationships [26].

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3 Methods

3.1 Study area selection

This study employs a qualitative case study methodology to examine the relevance of Nature-based Solutions (NbS) in the development of small-scale urban green spaces. The study adopts a case study methodology, which is particularly appropriate for investigating contemporary phenomena within their real-world context when the boundaries between phenomenon and context are not clearly evident [27]. The site of case study is Tanah Bengkok, Curug Kulon, which is currently an underused area with latent potential for ecological restoration and community activities. The case study method facilitates a comprehensive examination of the intricate socio-ecological dynamics affecting NBS implementation within the particular context of Curug Kulon [28].

Curug Kulon Sub-District in Tangerang Regency was chosen as the study area due to several factors: (1) the existence of underutilized green spaces, (2) the pressures of rapid urbanization, (3) the community's readiness to engage in the research, and (4) the feasibility of NbS implementation. The study area is about 15,330 square meters and is surrounded by a variety of land uses, such as residential areas, farmland, and empty lots.

3.2 Data collection methods

Data collection involved:

3.2.1 Focus group discussions

Focus group discussions were chosen as the principal qualitative data collection method due to their efficacy in examining community perceptions, preferences, and decision-making processes pertaining to environmental planning [29]. FGDs are especially useful for learning about the social and cultural factors that affect how well NBS interventions are accepted by the community [30].

Participants were chosen through purposive sampling to guarantee the inclusion of various stakeholder groups, such as local residents from diverse age ranges and socioeconomic backgrounds, community leaders, traditional authorities, and representatives from local government. In 2024, these talks happened three times: in August, September, and October.

3.2.2 Field observation and spatial analysis

Direct field observations were subsequently undertaken to map existing site conditions. The observational data were integrated with FGD and interview findings to identify ecological and infrastructural opportunities.

3.3 Data analysis

The data were analysed using thematic analysis and spatial mapping, with NbS principles serving as the analytical framework. The analysis consists of:

3.3.1 Area mapping

Making a map of Tanah Bengkok's potential and features in Curug Kulon Urban Village as a viewpoint to develop many aspects of green open space.

3.3.2 Participatory mapping and visioning

Participatory mapping were conducted to capture local knowledge about environmental conditions, land use patterns, and community priorities. The participants give clear ideas through FGD to identify areas of environmental concern, existing green spaces and their uses, preferred locations for NbS interventions and community assets and resources. Visioning were also conducted to develop shared goals and objectives for NbS implementation. Participants articulate their aspirations for environmental improvement and community development.

4 Results and discussion

There are important links between urban common property systems, social–ecological learning, and taking care of biodiversity and ecosystem services. Urban gardening programs give city communities more than just cultural and provisioning ecosystem benefits; they also give them regulatory ecosystem services [4]. To enhance food security, communities can directly use NbS in various ways to grow food. These methods can be used on land or water that is used for growing. Such an approach would help the 2030 Agenda reach many of its goals. Working with nature to keep people and their jobs safe might make the farming industry stronger. The recent study showed that ecosystem-based techniques for regenerative food systems may work up to 6.8 percent better than older methods when there are risks. But the farming industry needs more help and a better way to use solutions that come from nature. All sectors need to include them in plans and strategies for lowering disaster risk. Governments also need to do more to promote these healthy behaviours, like changing agricultural subsidies that make risks more likely. Not only governments, but also other influential individuals and groups must dedicate themselves to this cause. National disaster risk reduction platforms should be used to facilitate collaboration across sectors and levels. Using NbS in cities is a good way to protect them from possible disasters, lower the effects of heat islands, and improve the health and well-being of people who live there, among other things. Many experiences, pieces of information, research studies, and evaluations of policies are already available, even in numerous G20 countries [12].

4.1 Curug Kulon area mapping

According to local administrative authorities, Curug Kulon Village is distinguished by its long-standing heritage and unique characteristics. A prime example is the Curug Kulon Bird Market, which has become a defining identity for the area. Originally, the open space was frequently used by residents as a football field; over time, however, activities extended beyond sports. Driven by the community's passion for birds, several bird enthusiasts began to gather on this field, leading to the emergence of a bird trading activity.

There exists a 15,330 square meter area of unutilized land in Curug Kulon. From the eastern approach, the site is located 550 meters from the Curug Kulon Village Office (refer to Figure 1). The site can also be accessed from the western side via Jalan Padat Karya at a distance of 700 meters. The width of both access routes is limited, preventing four-wheeled vehicle access. This site was formerly a rice field area that has been gradually transformed as residential development expanded, rendering the remaining land inadequate for

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agricultural purposes. Surrounded by residential settlements and situated adjacent to major roadways, this open space represents a remaining vestige of Curug Kulon's extensive historical development and constitutes a potential area for preservation as an urban lung. According to Green Open Space (GOS) typological classifications, the spatial area corresponds to the designation of a District Park.

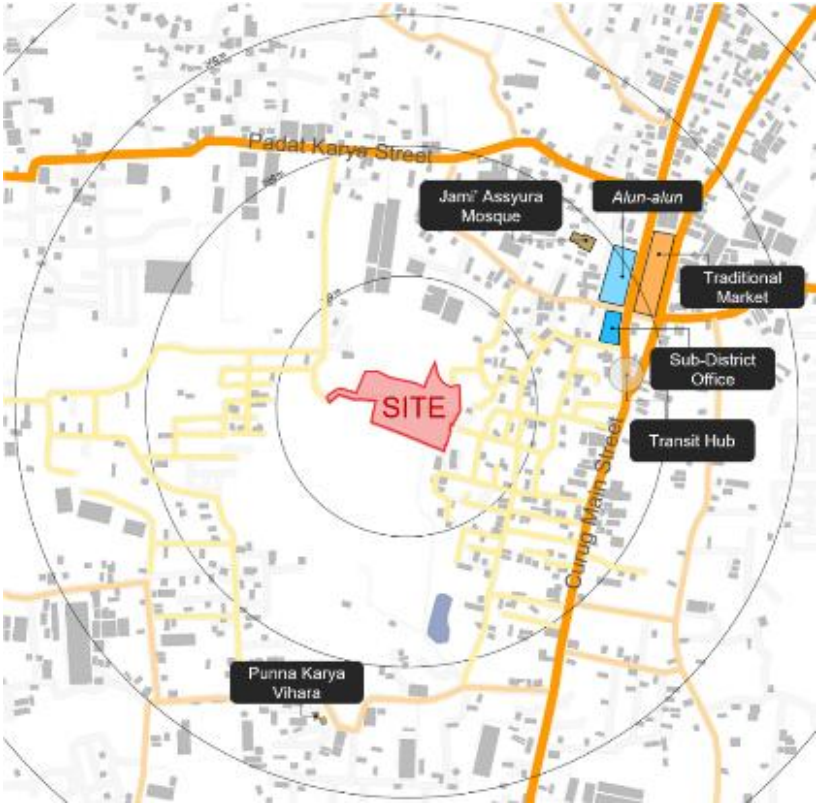


Fig.1. Spatial structure mapping.



Fig. 2. Site existing condition.

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4.2 Zoning results based on FGD

The authors did a survey of the current site, a Focus Group Discussion (FGD), and interviews with local stakeholders. The results revealed four distinct zones within the existing site:

4.2.1 Urban farming zone

The Women Farmers Group (KWT) runs this area. The Tangerang Regency Agriculture Department has officially recognized them as a farming group. The operational activities include rotating irrigation among 20 members on a set schedule. In the urban farming area, people grow long beans, mustard greens, tomatoes, chili peppers, water spinach, and cassava.

4.2.2 Household wastewater infiltration area

According to the testimony of the local Community Empowerment Institute (LPM) chairperson, there exists a household wastewater infiltration area within the site boundaries. Residential properties surrounding the site lack individual sewage disposal systems, consequently channeling wastewater into a designated portion of the site (indicated in red in Figure 2).

4.2.3 Former rice field ponds

The site contains former rice field areas that are no longer productive, forming permanent water bodies across portions of the site. Due to the abandonment of these areas, the perimeters of the former rice field ponds are utilized as household waste incineration sites. In Figure 2, this area is marked in yellow.

4.2.4 Wetland area

The majority of the remaining area consists of wetlands with water depths ranging from 1-1.5 meters. The entire area experiences flooding during heavy rainfall events. This condition is attributed to the blockage of the nearest drainage culverts surrounding the site and the site's topography, which is lower than the surrounding environment.



Fig. 3. Curug Kulon green open space condition.

Based on the Focus Group Discussion (FGD), the estimated spatial requirements have been compiled as presented in Table 1.

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Table 1. Spatial needs and requirements for Tanah Bengkok Curug Kulon.

No	User Group	Spatial Requirements	Existing Conditions	Proposed Solution
1	KWT (Women Farmers Group)	urban farming (agricultural productive space)	vegetable cultivation: long beans, mustard greens, tomatoes, chili, water spinach, cassava, bananas	potent educational space
2	LPM (Community Empowerment Institution)	wastewater infiltration system (infrastructure management)	covered drainage channels, flooding during rainfall	requires facilitation
		supporting infrastructure	-	sport facilities
3	PKK (Family Welfare Program)	supporting facilities (visitor services	-	restrooms, prayer room
4	villagers	plaza/ community space (cultural and economic activities)	existing bamboo weaving, calung traditional music, local food specialties (gethuk & rengginang) in surrounding area	micro-scale gallery, arts/crafts/food market, bird market events
		aviary/ animal zone	former rice fields and idle land	poultry and bird housing
		greening initiatives	No existing trees	garden



Fig. 4. Green open space zoning

The spatial zone focuses on the functional activities to be accommodated by providing temporal spaces that enable residents to organize sequential events such as bird markets, food and agricultural markets, and folk arts performances. The Green Open Spaces to be designed should emphasize naturalization concepts that encompass the development of thematic parks and the provision of retention and/or detention ponds to address stormwater runoff management. Appropriate spatial planning applications that are considered suitable can be observed in figure 5.



Fig. 5. Spatial planning application.

5 Results and discussion

The spatial analysis of the 15,330 m² Tanah Bengkok site identified four distinct zones: urban farming overseen by the Women Farmers Group (KWT), areas for household waste infiltration, former rice field ponds, and wetland regions. These results show that the site has a lot of environmental problems, such as flooding and drainage systems that don't work well, that need to be fixed right away with NbS interventions. The community involvement process, which included focus group discussions and interviews with stakeholders, showed that community-driven management of green spaces has a lot of potential. The 20-member KWT group runs urban farming activities that grow vegetables like long beans, mustard greens, tomatoes, chili, water spinach, and cassava. These activities are a good starting point for more community programs.

The research establishes a three-pronged NbS approach that addresses the core principles of climate adaptation, biodiversity conservation, and human well-being enhancement [8]:

- Climate adaptation: The spatial programming should integrate water retention areas and stormwater management techniques to address the site's flooding problems to create resilient infrastructure.
- Biodiversity conservation: It’s important to incorporates native planting schemes and biodiversity corridors that will restore ecosystem functions while providing educational opportunities for community.
- Human well-being enhancement: The spatial programming must accommodate diverse user needs through temporal spaces that enable community events such as bird markets, agricultural markets, and folk arts performances, transforming the site into a dynamic community hub.

6 Conclusion

This study suggests the incorporation of NbS principles into local urban planning policies, especially for regions classified as district-level parks based on RTH typology. Additionally, protocols for long-term monitoring and adaptive management should be put in place to make sure that NbS interventions keep working. The planning for Curug Kulon shows that NbS can be a powerful way to give communities more power when it is done through inclusive, participatory processes that take into account the current situation and local knowledge. The participatory framework established by this study offers a replicable model for green space

programming, serving as a foundation for the design of green open spaces confronting environmental degradation and social marginalization.

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